Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, D.C.

TSO-C20a

Effective
Date: 1/12/17

Technical Standard Order

Subject: ***Combustion Heaters and Accessories***

1. PURPOSE. This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration, (FAA)) tell you what minimum performance standards (MPS) your Combustion Heaters and Accessories must first meet for approval and identification with the applicable TSO marking.

2. APPLICABILITY. This TSO affects new applications submitted after its effective date.

a. TSO-C20 Amendment 1 will also remain effective until July 10, 2018. After this date, we will no longer accept applications for TSO-C20 Amendment 1.

b. Combustion Heaters approved under a previous TSOA may still be manufactured under the provisions of their original approval.

3. REQUIREMENTS. New models of Combustion Heaters identified and manufactured on or after the effective date of this TSO must meet the MPS qualification and documentation requirements in SAE International's Aerospace Standard AS8040B, Heater-Aircraft Internal Combustion Heat Exchanger Type, dated February 2013, as amended by appendix 1 and 2 of this TSO.

a. Functionality. This TSO's standards apply to equipment intended to provide heated air for civil aircraft.

b. Failure Condition Classification.

(1) Failure of the function defined in paragraph 3.a is a *major* failure condition.

(2) Loss of the function defined in paragraph **3.a** is a *minor* failure condition.

(3) Design the system to at least these failure conditions.

> **Note:** For Combustion Heater and Accessories, the maintenance and inspection items contained in the Instructions for Continued Airworthiness perform an important role in preventing failure resulting in combustion byproducts entering the cabin/flight deck.

c. Functional Qualification. Demonstrate the required performance under the test conditions of SAE International's Aerospace Standard AS8040B, Heater-Aircraft Internal Combustion Heat Exchanger Type, dated February 2013, as amended by appendix 1 of this TSO.

d. Environmental Qualification. Demonstrate the required performance under the test procedures in SAE AS8040B, Heater-Aircraft Internal Combustion Heat Exchanger Type, dated February 2013, as amended by appendix 1 of this TSO, using standard environmental conditions and test procedures appropriate for airborne equipment.

> **Note:** The use of RTCA/DO-160D (with Changes 1 and 2 only, with Change 3 incorporated) or earlier versions is generally not considered appropriate and will require substantiation via the deviation process as discussed in paragraph **3.g** of this TSO.

e. Software Qualification. If the article includes software, develop the software according to the latest FAA accepted revision to Advisory Circular 20-115 RTCA, Inc. document RTCA/DO-178C, Software Considerations in Airborne Systems and Equipment Certification, including referenced supplements as applicable, to at least the software level consistent with the failure condition classification defined in paragraph 3.b of this TSO. You may also develop the software according to RTCA, Inc. document RTCA/DO-178B, dated December 1, 1992, if you follow the guidance in AC 20-115C, Airborne Software Assurance, dated July 19, 2013.

f. Electronic Hardware Qualification. If the article includes complex custom airborne electronic hardware, develop the component according to the latest FAA accepted revision to *RTCA, Inc. Document RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware* to at least the design assurance level consistent with the failure condition classification defined in paragraph **3.b** of this TSO. For custom airborne electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.

g. Deviations. We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation under the provision of Title 14, Code of Federal Regulations (14 CFR) § 21.618.

4. MARKING.

a. Mark at least one major component permanently and legibly with all the information in 14 CFR § 45.15(b)

b. Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly number, and the TSO number.

(1) Each component that is easily removable (without hand tools); and,

(2) Each subassembly of the article that you determined may be interchangeable.

c. If the article includes software and/or airborne electronic hardware, then the article part numbering scheme must identify the software and airborne electronic hardware configuration. The part numbering scheme can use separate, unique part numbers for software, hardware, and airborne electronic hardware.

d. If the Combustion Heater includes a deviation per paragraph **3.g** of this TSO, the marking must include a means to indicate a deviation was granted.

5. APPLICATION DATA REQUIREMENTS. You must give the FAA aircraft certification office (ACO) manager responsible for your facility a statement of conformance, as specified in 14 CFR § 21.603(a)(1) and one copy each of the following technical data to support your design and production approval. LODA applicants must submit the same data (excluding paragraph **5.h**) through their civil aviation authority.

a. Manual(s) containing the following:

(1) Operating instructions and equipment limitations sufficient to describe the equipment's operational capability.

(2) Description in detail of any deviations.

(3) Installation instructions and limitations sufficient to ensure that the Combustion Heater, when installed according to the installation or operational instructions, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must include a note with the following statement:

> "This article meets the minimum performance and quality control standards required by a technical standard order (TSO). Installation of this article requires separate approval."

(4) For each unique configuration of software and airborne electronic hardware, submit the following to the ACO:

(a) Software part number including revision and design assurance level;

(b) Airborne electronic hardware part number including revision and design assurance level; and,

(c) Functional description.

(5) A summary of the test conditions used for environmental qualifications for each component of the article.

(6) Schematic drawings, wiring diagrams, and any other documentation necessary for installation of the Combustion Heater.

(7) List of replaceable components, by part number, that makes up the Combustion Heater. Include vendor part number cross-references, when applicable.

b. Instructions covering periodic maintenance, calibration, and repair, to ensure that the Combustion Heater continues to meet the TSO approved design. Include recommended inspection intervals and service life, as appropriate.

c. If the article includes software: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary.

d. If the article includes simple or complex custom airborne electronic hardware: a plan for hardware aspects of certification (PHAC), hardware verification plan, top-level drawing, and hardware accomplishment summary (or similar document, as applicable).

e. A drawing depicting how the article will be marked with the information required by paragraph **4** of this TSO.

f. Identify functionality or performance contained in the article not evaluated under paragraph **3** of this TSO (that is, non-TSO functions). Non-TSO functions are accepted in parallel with the TSO authorization. For those non-TSO functions to be accepted, you must declare these functions and include the following information with your TSO application:

(1) Description of the non-TSO function(s), such as performance specifications, failure condition classifications, software, hardware, and environmental qualification levels. Include a statement confirming that the non-TSO function(s) do not interfere with the article's compliance with the requirements of paragraph **3**.

(2) Installation procedures and limitations sufficient to ensure that the non-TSO function(s) meets the declared functions and performance specification(s) described in paragraph **5.f.(1)**.

(3) Instructions for continued performance applicable to the non-TSO function(s) described in paragraph **5.f.(1).**

(4) Interface requirements and applicable installation test procedures to ensure compliance with the performance data defined in paragraph **5.f.(1).**

(5) Test plans, analysis and results, as appropriate, to verify that performance of the hosting TSO article is not affected by the non-TSO function(s).

(6) Test plans, analysis and results, as appropriate, to verify the function and performance of the non-TSO function(s) as described in paragraph **5.f.(1).**

g. The quality system description required by 14 CFR § 21.608, including functional test specifications. The quality system should ensure that you will detect any change to the approved design that could adversely affect compliance with the TSO MPS, and reject the article accordingly. (Not required for LODA applicants.)

h. Material and process specifications list (including revision level).

i. List of all drawings and processes (including revision level) that define the article's design.

j. Manufacturer's TSO qualification report showing results of testing accomplished according to paragraph **3.c** of this TSO.

6. MANUFACTURER DATA REQUIREMENTS. Besides the data given directly to the responsible ACO, have the following technical data available for review by the responsible ACO:

a. Functional checks and acceptance test results for qualifying each production article to ensure compliance with this TSO.

b. Article calibration procedures.

c. Schematic drawings.

d. Wiring diagrams.

e. The results of the environmental qualification tests conducted according to paragraph **3.d** of this TSO.

f. If the article includes software, the appropriate documentation defined in the latest FAA accepted revision of RTCA/DO-178 including all data supporting the applicable objectives in RTCA/DO-178 *Annex A, Process Objectives and Outputs by Software Level*.

h. If the article includes complex custom airborne electronic hardware, the appropriate hardware life cycle data in combination with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-l. For simple custom airborne electronic hardware, the following data: test cases or procedures, test results, test coverage analysis, tool assessment and qualification data, and configuration management records, including problem reports.

i. If the article contains non-TSO function(s), you must also make available items **6.a** through **6.h** as they pertain to the non-TSO function(s).

7. FURNISHED DATA REQUIREMENTS. If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), ensure that entity has free access to the following:

a. If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide one copy or on-line access to the data in paragraphs **5.a** and **5.b** of this TSO. Add any other data needed for the proper installation, certification, use, or for continued compliance with the TSO, of the Combustion Heater.

b. If the article contains declared non-TSO function(s), include one copy of the data in paragraphs **5.f.(1)** through **5.f.(4).**

8. HOW TO GET REFERENCED DOCUMENTS.

a. Order RTCA documents from RTCA Inc., 1150 18th Street NW, Suite 910, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at www.rtca.org.

b. Order SAE documents from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Telephone (724) 776-4970, fax (724) 776-0790. You can also order copies online at www.sae.org.

c. Order copies of 14 CFR parts 21 and 45 *{add additional applicable parts}* from the Superintendent of Documents, Government Printing Office, P.O. Box 979050, St. Louis, MO 63197. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies online at www.access.gpo.gov. Select "Access," then "Online Bookstore." Select "Aviation," then "Code of Federal Regulations."

d. You can find a current list of technical standard orders and advisory circulars on the FAA Internet website Regulatory and Guidance Library at http://rgl.faa.gov. You will also find the TSO Index of Articles at the same site.

Susan J. M. Cabler
Acting Manager, Design, Manufacturing, &
Airworthiness Division
Aircraft Certification Service

APPENDIX A - MPS FOR COMBUSTION HEATER BASED ON SAE AS 8040B

This appendix prescribes the MPS for Combustion Heaters. The applicable standard is SAE International's Aerospace Standard (AS) 8040B, Heater-Aircraft Internal Combustion Heat Exchanger Type, dated February 2013. We modified it as follows:

Section: 3. Accessories

3.2.a. Includes fuel/air ratio controller, fuel lines and preheater.

3.2.b. Rewritten to read "Ignition System: The ignition system uses an aircraft supplied energy source to enable proper functioning of the igniter. Examples of accessory devices that may be utilized in a heater ignition system include but are not limited to:"

3.2.b.2. Replaces the term "spark plug" with "igniter".

3.2.b.3. Removes the statement, "Heaters with output ratings of 11,700 W (40,000 Btu/hour) or less may use an electrically heated resistance wire as an ignition source."

3.2.c. Includes the requirement, "Any component whose failure could lead to an unsafe condition, such as ducting, that is in a fire zone must be fireproof."

3.2.c. Includes ducting/tubing, combustion air blower, combustion air flow sensor, ventilation air flow sensor, and air flow/pressure regulator.

3.2.d.1. Revised to read, "Cabin temperature controls".

3.2.e. Includes a device to sense differential pressure across the combustion chamber, a device to sense combustion, a device that senses excessive combustion byproducts in the ventilation air, a device to shut off fuel flow when required, and a device to alert crew that a safety system engaged.

3.3.2. Includes the phrase, "having the capacity to withstand at least as well as .015" thick stainless steel, the heat produced when there is a severe fire of extended duration."

3.5. Includes service ceiling.

3.6. Includes the statement, "It is best practice to set inspection, maintenance and/or replacement intervals based on individual component performance during design qualification testing (such as endurance testing).

Section: 4. Detail Requirements

4.3.1. Replaces “gasoline or aviation grade kerosene, or both” with “fuel”.
4.3.4. Adds “fittings and controls” after “All fuel lines”.

4.3.5. Replaces “no lead or low lead type gasoline and kerosene” with the word “applicable”. Adds “Low starting temperature limits for other types of fuels need to be addressed on a case-by-case basis.” to the end of this paragraph.

4.5. Replaces “649^{o}C (1200^{o}F)” with “material capabilities in this section of the heater”. Adds the sentence, “Best practice is to ensure that the temperature at the point of discharge shall not exceed 649 °C (1200 °F). Consideration should also be given to the impact of heat impingement on the aircraft region surrounding the Combustion Heater.” to the end of the paragraph.

4.6.3. Adds to the end of the paragraph the following: “or heated solid surface, though it is not considered a best practice to use resistance wires as an ignition sources for power levels above 11,700 W.”

4.6.8. Adds the statement, “Other types of fuels need to be addressed on a case-by-case basis.” to the end of the paragraph.

4.6.9. Adds the statement, “Other types of fuels need to be addressed on a case-by-case basis.” to the end of the paragraph.

4.7.d. Replaced with this paragraph: “These safety controls shall be independent of the controls normally used to control heater operation. The shut off of ignition and fuel shall occur at a point remote from the heater itself. The Combustion Heater shall have a means to warn the crew when any heater whose heat output is essential for safe operation has been shut off by the automatic means. The requirement to shut off ignition and fuel at a point remote from the heater until restarted by the crew, may require a safety interlock relay and additional fuel shut off device be supplied in addition to the valve usually supplied with the heater as an accessory. This relay and valve are the responsibility of the installer. See 5.2.10.6 for tests conducted on safety controls.”

4.9. Adds at end of first paragraph: “Use electrical load analysis to show the worst-case situation is safe to operate.”.

4.12. Adds a new paragraph:
Radio Interference

4.12.1 If the manufacturer elects to demonstrate compliance with standard radio interference requirements, it is considered a best practice to test the Combustion heat Exchanger per RTCA DO-160F Chapter 21, or later FAA accepted revision, and report the result in the aircraft flight manual supplement.

4.12.2 If the manufacturer elects not to demonstrate compliance with radio interference requirements, the manufacturer shall include in the Combustion heat Exchanger aircraft flight manual supplement the following statement:

"This Combustion Heat Exchanger assembly does not include protection against nor it is tested for radio and/or avionics interference"

Section: 5 Required Testing

Initial paragraph includes the statement, "Test plans and reports shall be generated and retained for the life of the design."

5.2.2.2. Revised to include, "A suitable instrument with a resolution no higher than 5 ppm, calibrated against a known standard, will be used to determine CO concentration."

5.2.2.3. Adds the statement, "A pressure decay test may alternatively be used provided that the decay rate can be determined to be equivalent to the requirements listed above." at the end of the paragraph.

5.2.3. Replaces:
"The service ceiling determined by this test shall meet the requirement specified by the purchaser."
With:
"It is typical for a Combustion Heater's service ceiling to be at least 6100 m (20,000 feet), and in order to ensure an adequate margin with this test being done on only one heater, a safety margin of 5% shall be applied. Therefore, in order to set a service ceiling of 6,100 m (20,000 feet) the peak of the ignition characteristics curve shall be no lower than 6,405 m (21,000 feet)."

5.2.4. Replaced with the following:

"Install the test unit in to the test set up used in 5.2.2.1. and cold-soak the Combustion Heater assembly to -54 °C (-65 °F) for gasoline type heaters and -29 °C (-20 °F) for kerosene type heaters (for other fuel types, the applicable temperature will be determined on a case-by-case basis). The valve leakage in the closed position with either rated fuel pressure or minimum practical fuel pressure shall not exceed 0.068 fluid ounces (2 mL) of fuel in 10 minutes. Supply combustion air and ventilating air to the heater at sea level pressure and -54 °C (-65 °F) temperature. The fuel temperature supplied to the heater shall be -54 °C (-65 °F) for gasoline type heaters and -29 °C (-20 °F) for kerosene type heaters. Combustion and ventilating air pressure levels and mass flow rates shall be the same as 5.2.2.1. Glow plug ignited heaters shall ignite within 200 seconds. Spark ignited heaters shall ignite within 15 seconds when burning gasoline type fuels, and within 60 seconds when burning kerosene type fuels. Measure and record the parameters specified in 5.2.2.1."

5.2.10.6.2.1. Includes the following statement after the first sentence in the second paragraph: "Leakage through the fuel valve shall then be measured and shall not exceed 0.068 fluid ounces (2 mL) in 10 minutes."

Section: 6 Desirable Features

6.1.2 Includes the statement "Other types of fuels need to be addressed on a case-by-case basis."

APPENDIX B - INSTRUCTIONS for CONTINUED AIRWORTHINESS of the AIRCRAFT COMBUSTION HEATER AND ACCESSORIES

1.0 The following information contained in this Appendix must be included into the manual, as required by paragraph 5.b. of this TSO to ensure the Combustion Heater and Accessories continues to meet the TSO once it is installed in a product.

1.1 Scheduling information for each part of the Combustion Heater stating inspection criteria and service limits. Necessary cross-references to the Airworthiness Limitations section must also be included.

1.2 Troubleshooting information describing probable malfunctions, how to recognize and resolve those malfunctions.

1.3 Information describing the order and method of removing and replacing parts, the order and method of disassembly and assembly, with any necessary precautions to be taken.

1.4 Cleaning and inspection instructions that cover the material and apparatus to be used and methods and precautions to be taken. Methods of inspection must also be included.

1.5 Details of repair methods for worn or otherwise substandard parts and components along with the information necessary to determine when replacement is necessary.

1.6 Instructions for testing including test equipment and instrumentation.

1.7 A list of the tools and equipment necessary for maintenance and guidance for their use.

1.8 Instructions on how to ensure the Combustion Heater assembly is fit for return to service after maintenance and prior to installation (for example, procedures for a pressure decay test).